

# PHYLLOCARID CRUSTACEANS FROM THE SILURIAN AND DEVONIAN OF CZECHOSLOVAKIA

by IVO CHLUPÁČ

**ABSTRACT.** Recent discoveries of phyllocarids in the Silurian and Devonian of the Barrandian area in Bohemia and the Upper Devonian of the Moravian Karst area are described. Nearly complete specimens of *Aristozoa parabolica* Perner and *Pygocaris schuberti* Perner have been found, permitting a more detailed diagnosis of the family Aristozoidae, to which the genus *Heroldina* Broili has also been referred. *Ceratiocaris cornwalliensis damesi* subsp. nov. from the Czech Silurian and *Ceratiocaris* (?) *coherbaria* sp. nov. from the Middle Devonian are described.

*Concavicaris desiderata* (Barrande) from the Czech Middle Devonian and *C. incola* sp. nov. from the Moravian Upper Devonian are described and assigned to the genus *Concavicaris* Rolfe (formerly *Colpocaris* Meek), previously known only from the American Carboniferous. The systematic position of the genus *Montecaris* Jux is discussed and the description of *M. brunnensis* Chlupáč is amplified.

PHYLLOCARIDS from the Silurian and Devonian of Czechoslovakia are known partly from the classical Barrandian area in central Bohemia and partly from the Moravian Karst area in central Moravia. In the Barrandian area phyllocarids have been discovered in beds of Silurian, Lower and Middle Devonian age; in the Moravian older Palaeozoic rocks they have so far been found only in the Upper Devonian.

The fundamental description of the Bohemian Silurian and Devonian phyllocarids was published in J. Barrande's appendix to the first volume of his *Système silurien du centre de la Bohème* (1872). Important facts about Bohemian phyllocarids were added in papers by Novák (1885a, b; 1886a, b), but Novák died before his large prepared work was published. In this century Perner (1916, 1919) has studied the Czech phyllocarids and described new forms from the uppermost Silurian, and Gürich (1929) has discussed questions of systematics. Otherwise, with the exception of the author's brief communication (1960b), the interesting phyllocarid fauna of the Bohemian Silurian and Devonian has not been studied by modern methods. In the recent literature only sporadic mention can be found of the occurrence of single species, e.g. Bouček (1938), Prantl and Příbyl (1948), and Chlupáč (1953, 1955).

In Moravia the first remains of phyllocarids were only recently discovered in the Upper Devonian of the southern part of the Moravian Karst (Chlupáč 1960b).

During new systematic researches in the Silurian and Devonian of central Bohemia as well as in the Devonian of Moravia we have succeeded in finding numerous further specimens. These finds of more completely preserved individuals of formerly known species or of new forms improve our knowledge of the Czechoslovakian phyllocarid fauna. The present paper deals with some finds of systematic and stratigraphical importance.

*Acknowledgements.* For this study the Bohemian Silurian material from the collections of Diplomgeologist R. Horný, F. Kalfus, Dr. M. Šnajdr, and J. Vaněk was used besides the material collected by the author. The author wishes to thank Miss O. Hofmanová for allowing him to study her specimens from the Devonian of the Moravian Karst. Professor Dr. R. Kettner and Diplomgeologist J. Obrhel made it possible for the author to study the older material from the collections of the Geological-Palaeontological Institute of the Charles University, and R. Horný gave access to the originals in the

Barrandeum of the National Museum of Czechoslovakia. The author wishes to express his thanks to all the above-mentioned scientists for their willingness and understanding as well as his sincere appreciation to Dr. W. D. I. Rolfe, Hunterian Museum, University of Glasgow, for his kind comments and help in the comparative study of phyllocaris.

*Repositories.* The described material is deposited mainly in the author's collection in the Central Geological Institute in Prague (in the text abbreviated to ICh). Other specimens used in the paper are in the collections of the National Museum in Prague (abbreviated to NM) and Geological-Palaeontological Institute of the Natural Science Faculty of the Charles University (abbreviated to KU). The photographs were made by R. Horný (National Museum, Prague) and H. Váňová (Central Geological Institute, Prague).

#### SYSTEMATIC DESCRIPTIONS

Order PHYLLOCARIDA Packard 1879  
Suborder CERATIOCARINA Clarke 1900  
Family ARISTOZOIDAE Gürich 1929

The representatives of this family have been known only on the basis of isolated parts of the carapace. New finds of almost complete specimens of the genus *Aristozoe* Barrande and *Pygocaris* Perner, in which the carapace, abdomen, and telson are preserved connected in their original position, make it possible to improve the diagnosis of the family.

*Revised diagnosis.* Carapace bivalved, with prominent nodes in the anterior part and distinct marginal rim. Small number (3, in *Heroldina* 5) of abdominal segments preserved outside the carapace, the last of which is strikingly elongated. The caudal part consists of one long spine only—a telson, which is usually dorso-ventrally curved. Furca not found.

*Remarks.* The bivalved carapace without a dorsal plate and free rostrum of genera of the family Aristozoidae proves that they belong to the suborder Ceratiocarina. The most outstanding feature of the family is that the caudal portion is formed by a single spine, the telson, usually curved, while traces of the furca have not been ascertained even in complete, well-preserved individuals (e.g. even of the genus *Heroldina*). Novák (1886*b*), who first called attention to the absence of furca, had, however, only isolated carapaces at his disposal. In this the representatives of the family Aristozoidae differ not only from other families of the suborder Ceratiocarina, but also from other phyllocarids and archaeostracans in general, to which according to other features they undoubtedly belong. In any case the family Aristozoidae Gürich represents an independent group, markedly differentiated from other families but showing closest relation to the suborder Ceratiocarina Clarke, especially to the family Echinocarididae Clarke. The configuration of the caudal part in the family Aristozoidae is, however, an exceptional phenomenon among the Archaeostraca. The new discoveries indicate that we cannot regard the assignment of the genus *Aristozoe* and other related genera to ostracods given by Barrande (1872) and in the *Treatise on Invertebrate Paleontology*, Part Q (Moore 1961), as correct. The comments of W. D. I. Rolfe (*ibid.*, p. Q429) are, therefore, more than justified.

*Genera.* The genera *Pygocaris* Perner and *Orozoe* Barrande belong to the family Aristozoidae together with the type genus *Aristozoe* Barrande. The genus *Heroldina* Broili without any doubt belongs here. It agrees with *Aristozoe* and *Pygocaris* in having a

greatly elongated last abdominal segment and especially in having the characteristic caudal part represented by the single curved telson (Broili 1929). To this family the author refers the genus *Callizoe* Barrande only with reserve, the nodes of which are situated more antero-ventrally than in other genera and the valves show weak lateral carinae.

Genus *Aristozoe* Barrande 1872

*Aristozoe parabolica* Perner 1919

Plate 13, figs. 1–3; text-fig. 1

1916 *Aristozoe parabolica* Perner, pp. 5, 6, pl. 1, figs. 9–11 (Czech description).

1919 *Aristozoe parabolica* Perner, p. 228, pl. 1, figs. 9–11 (German description).

1929 *Aristozoe parabolica* Perner; Gürich, p. 62, text-figs. 7–14.

1934 *Aristozoe parabolica* Perner; Straelen and Schmitz, p. 100.

*Lectotype*. Perner 1919, pl. 1, figs. 9–11, NM Br042.

*Type locality*. Kosoř, near Praha, Czechoslovakia.

*Horizon*. Lochkov formation, Radotín-Limestones facies, Lochkovian, Zone of *Monograptus hercynicus*, Silurian.

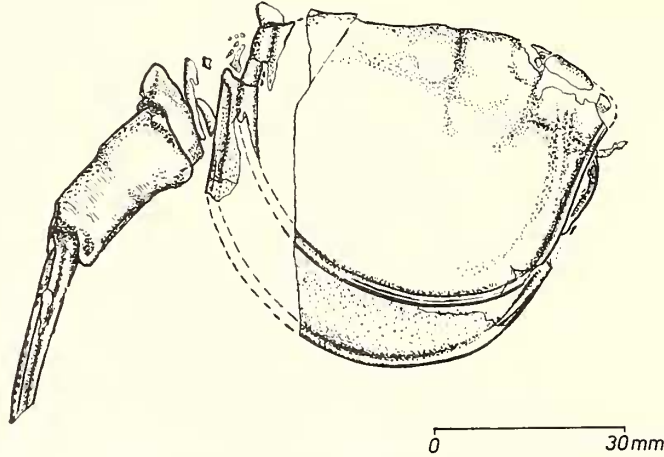
*Emended description*. The description of the carapace was given by Perner (1916, 1919). The main features of the carapace are the characteristic and almost parabolic outline of the ventral border of the valves, the closeness of the length to the width of the valves (5:4 to 8:7), an obliquely truncate postero-lateral region, a narrow marginal rim, two nodes in the antero-dorsal region, the posterior one larger and more convex than the anterior one, semi-elliptical, and dorso-ventrally elongated. It is necessary, however, to add to Perner's description and illustrations that the postero-dorsal border is not so broadly rounded as Perner states. The original depicted in Perner's pl. 1, fig. 9 is badly damaged and incompletely preserved in the postero-dorsal part (in the positive entirely broken off), and in this respect the illustration is wrongly reconstructed. From better-preserved specimens (see Pl. 13, figs. 2, 3) it is evident that the marginal rim extends as far as the dorsal border, where the postero-dorsal angle is obtuse.

The recent material (coll. ICh 105) presents a strongly compressed specimen of *A. parabolica*, in which besides the carapace even the abdominal segments and telson in natural position are preserved (see text-fig. 1). The carapace of this individual is ill preserved owing to flattening. The assignment to *A. parabolica* can be proved by the outline preserved in greater part, a narrow marginal rim and smooth surface (the nodes rendered indistinct by deformation). The right and the left valves of the carapace of this individual overlap each other only partially: the left valve was posthumously displaced ventrally relative to the right valve so that a considerable part of the ventral sector of the left valve remains uncovered by the right valve, causing the apparently unusually large dorso-ventral width of the carapace. In the antero-dorsal part two free portions of the carapace are observed which could be interpreted as a broken rostrum. Owing to the strong compression of the valves the possibility that these are secondarily separated fragments of the antero-dorsal part of the carapace cannot be excluded.

Outside the carapace, in addition to the telson, fragments of three abdominal segments have been preserved. The first has been preserved only as three isolated fragments of the posterior part of the segment. The second segment has been preserved more completely, its width considerably exceeding its length (approx. 1:3) while the outline shows that in



the dorsal part the segment was longer than in the ventral. The postero-dorsal part is pointed and projects postero-dorsally. The last abdominal segment is considerably elongated, about four times longer than the penultimate one. The proportion between sagittal length and width after lateral compression is 2:1. At the proximal border of the segment in the antero-dorsal part there is a swelling, which in spite of the compression is clearly perceptible. At a distance of 9 mm. from the proximal end of the last segment runs a dorso-ventral transverse furrow which could possibly be considered as a dividing-



TEXT-FIG. 1. *Aristozoe parabolica* Perner. ICh 105, laterally compressed specimen with abdomen in natural position, left valve of the carapace displaced ventrally.

line between two abdominal segments. The fact that the dividing-line is interrupted in the middle and that the distinct swelling characteristic of the anterior part of the last segment cannot be found near this line is incompatible with this interpretation. The analogy with the closely related genus *Pygocaris* Perner also tends against this explanation. Slight traces of dorso-ventrally running irregular transverse striae are preserved on the last segment.

The telson, which is articulated with the last abdominal segment and lacks the distal part, shows a slight dorso-ventral curvature. It bears two distinct small longitudinal ridges; at the dorsal border traces of insertions of bristles are partly preserved. Remains of the furca have not been found.

*Dimensions.* ICh 105 (Pl. 13, fig. 1; text-fig. 1), max. length of the carapace 55 mm., dorso-ventral width of the carapace 42 mm., length of the abdominal part without telson 35 mm. Length of the last abdominal segment 24 mm., width of the last abdominal segment 11 mm. ICh 102 (Pl. 13, figs. 2, 3), max. length of the carapace 47 mm., width 38 mm.

*Remarks.* *A. parabolica* Perner has hitherto been known only on the basis of isolated valves of the carapace. The described specimen with preserved abdominal part, in spite of its less favourable and somewhat incomplete preservation, is of considerable significance as it constitutes the first specimen of *Aristozoe* in which carapace and abdominal part of the body are preserved in natural position. This confirms to a great extent the correctness of Novák's reconstruction (1885) which was made on the basis of isolated



carapaces and segments of *A. regina* Barrande from the Lower Devonian. It is significant that only a small number (3) of abdominal segments was observed, which is analogous with *Pygocaris* Perner and obviously characteristic of the family Aristozoidae.

From the Lochkov Formation of the Kosoř locality Novák (1886*b*, pp. 15, 16) described a minute isolated telson with longitudinal ridges which he designated as *Aristozoe solitaria* Novák. His specimen agrees with the telson of *A. parabolica* described above in having distinct small longitudinal ridges, dorso-lateral insertions of bristles, and a slight curvature. The incomplete preservation of the telson of *A. parabolica* precludes identification of the species with *A. solitaria*, especially since in the same strata several related phyllocarids occur together.

*Occurrence.* *A. parabolica* has so far been found only at the classical locality in the Silurian–Devonian boundary beds near Kosoř (quarries at Černá rokle). All known finds come from the blackish-grey thin-bedded fine-grained limestones and dark calcareous shales which alternate with the limestones. The beds belong to the Lochkovian (i.e. to the Lochkov Limestones in the Radotín facies), *Monograptus hercynicus* Zone, uppermost Silurian. The beds are probably younger than the British Upper Ludlovian as mentioned by Boucot (1960). They are assigned to the uppermost Silurian in accordance with the conclusion of the Prague symposium (Svoboda 1958). Specimens are not abundant; about twenty discoveries have so far been made, and except for one whole described specimen consist of valves of the carapace only.

#### Genus *Pygocaris* Perner 1919

#### *Pygocaris schuberti* Perner 1919

Plate 12, fig. 8; Plate 13, figs. 4, 5; text-fig. 2

1916 *Pygocaris schuberti* Perner, pp. 2–5, pl. 1, figs. 1–5 (Czech description).

1919 *Pygocaris schuberti* Perner, pp. 226, 227, pl. 1, figs. 1–5 (German description).

1929 *Pygocaris schuberti* Perner; Gürich, pp. 54, 62; text-pl. 5, fig. 16.

1934 *Pygocaris schuberti* Perner; Straelen and Schmitz, p. 193.

1960 *Pygocaris schuberti* Perner; Krestovnikov, p. 428, fig. 1254.

*Lectotype.* Perner 1916, 1919, pl. 1, figs. 1–4, NM Čel593.

*Type locality.* Kosoř, near Praha, Czechoslovakia.

*Horizon.* Lochkov Formation, Radotín-Limestones facies, Lochkovian, Zone of *Monograptus hercynicus*, Silurian.

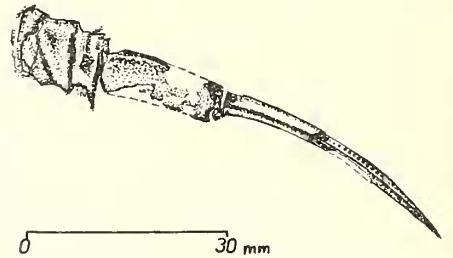
*Emended description.* Perner (1916, 1919) described the carapace as possessing the following distinctive features: a prominent tapered-off projection at the anterior border of the valves and a tapering postero-dorsal part of the valves; an outstanding and fairly broad marginal rim separated off by a deep border groove; a greater number (4?) of nodes in the antero-dorsal region; and a characteristic ornamentation formed by prominent longitudinal anastomosing and often bent small ridges of unequal length.

Besides a number of carapaces which confirm the description given by Perner, a young specimen has been found among the new material in which the carapace, abdominal segments, and telson are preserved in the natural position (ICh 100, Pl. 12, fig. 8; Pl. 13, figs. 4, 5), and which allows Perner's specific description to be amplified. The specimen is preserved in a lateral position and is strongly compressed laterally so that the carapace

does not show the original convexity. Only the posterior half of the carapace is preserved, and by its characteristic outline, postero-dorsally tapering, broad marginal rim, and traces of striation preserved at the dorsal border of the carapace, clearly belongs to *P. schuberti*.

Outside the carapace traces of three abdominal segments are preserved in addition to the telson. The first, having been evidently partly covered by the carapace, is incompletely preserved; only the posterior, thickened border of the segment, running subparallel to the posterior border of the carapace, is more distinct. Being laterally compressed the second segment has an almost sub-trigonal outline and the dorsal border was evidently longer than the ventral border. The length at the dorsal border approximately equals the dorso-ventral length. As in *A. parabolica* the segment terminates posteriorly in a postero-dorsal projection. The last abdominal segment, unlike the previous ones, is well preserved despite the lateral compression. The length of the segment is conspicuous; it is two and a half times longer than the dorso-ventral width. At the anterior border the segment was evidently more massive, as shown by its convex surface. At the antero-ventral border a laterally situated node is preserved; the swelling of the segment and the elevation of this part are possibly due to muscular insertions. The postero-dorsal border of the segment may have run out in a short caudal projection which partly overlapped the head of the telson.

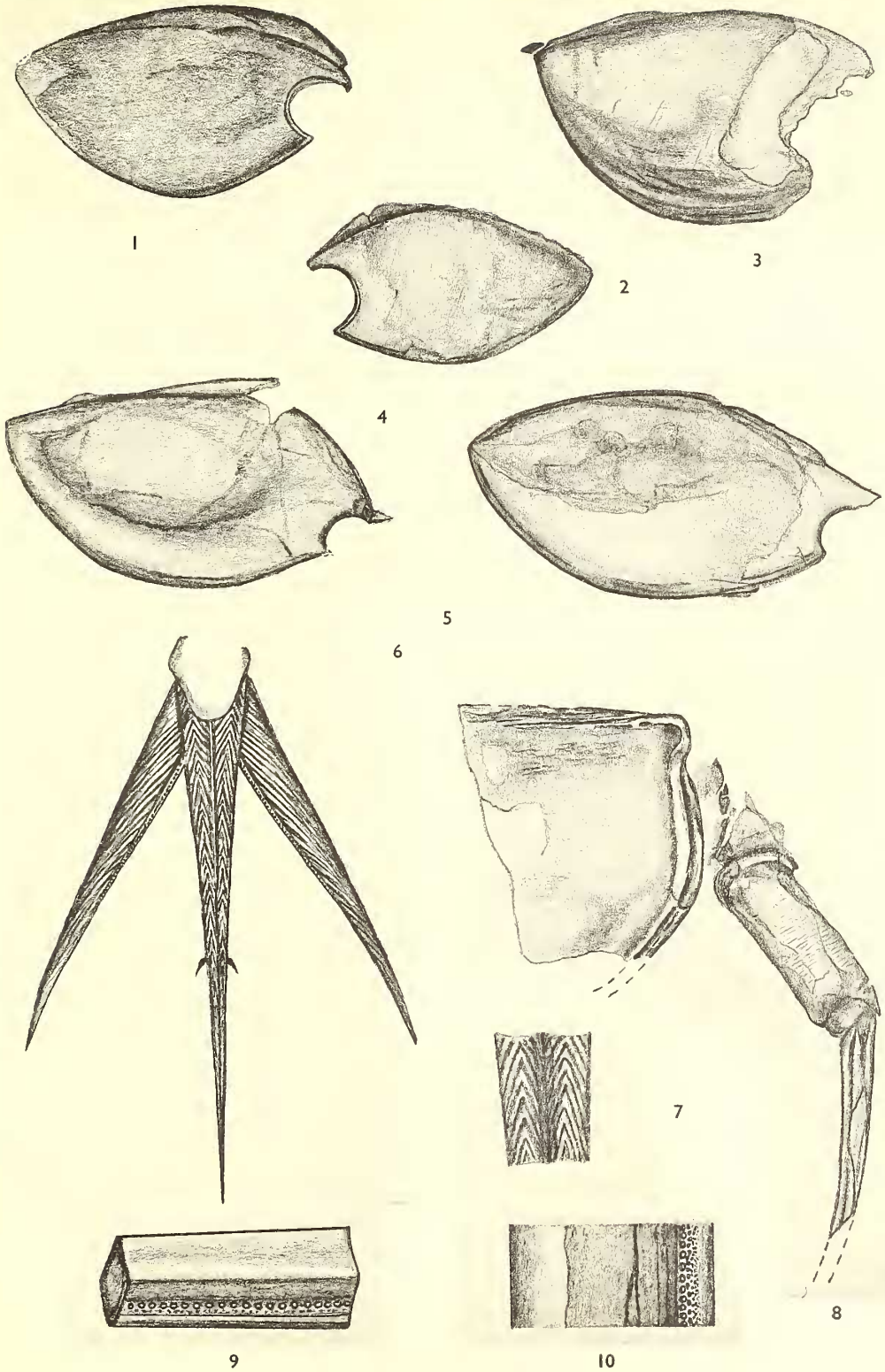
The head of the telson was articulated with the posterior border of the last segment, which was embayed. On the surface of the last segment an ornament is perceptible formed by dorso-ventrally running, slightly undulating, small ridges. This type of ornament corresponds well with the sculpture of the surface of the carapace in *P. schuberti*. Only the proximal half of the telson is preserved. It is distinctly bent in the dorso-ventral direction and carries two longitudinal ridges. The head is slightly enlarged and the spine tapers gradually backwards. Traces of bristle insertions are not preserved. Furcal rami have not been found, although the articulation between the last abdominal segment and telson is well preserved.



TEXT-FIG. 2. *Pygocaris schuberti* Perner. ICh 110, laterally compressed abdomen.

#### EXPLANATION OF PLATE 12

- Figs. 1, 2. *Concavicaris incola* sp. nov. Hády, near Brno. 1, Holotype, ICh 176, carapace (left valve),  $\times 2.6$ . 2, Paratype, ICh 178a, carapace (right valve),  $\times 2.3$ .  
 Figs. 3-5. *Concavicaris desiderata* (Barrande). Pekárek mill, near Choteč. 3, Paratype D, ICh 193, left valve of the carapace showing the rostral plate,  $\times 2.5$ . 4, Paratype A, ICh 194, carapace (left valve),  $\times 2.6$ . 5, Paratype B, ICh 192, carapace (left valve),  $\times 3$ .  
 Figs. 6, 7. *Ceratiocaris (?) coherbaria* sp. nov. Karlštejn. 6, Restored telson and furca, after holotype, ICh 126a,  $\times 2$ . 7, Detail showing the sculpture of the telson, after ICh 123,  $\times 4.6$ .  
 Fig. 8. *Pygocaris schuberti* Perner. Kosoř, near Praha. Paratype A, ICh 100. Incompletely preserved carapace, abdominal segments and telson in natural position,  $\times 1$ .  
 Figs. 9, 10. *Ceratiocaris cornwallisensis damesi* subsp. nov. 9, Paratype, ICh 137, detail of the distal portion of telson (lateral view) showing pits marking points of insertion of bristles situated ventrolaterally; Šamor near Liteň;  $\times 4.7$ . 10, Paratype, ICh 250, detail of compressed telson showing the stripe of pits marking points of insertion of bristles; Kosoř;  $\times 2$ .



CHLUPÁČ, Phyllocarid crustaceans





The shape of the abdominal part of the carapace is also visible in another specimen (ICh 110), which, by analogy with that described above, the author also refers to *P. schuberti*. It is an isolated flattened abdomen with telson, preserved in lateral position (text-fig. 2). In addition to the telson three abdominal segments are clearly visible; the first two are much shorter than the last. The last segment is more than three times longer than it is wide; it is, however, impossible to exclude deformation caused by compression. The telson, characteristically slightly but distinctly dorso-ventrally curved, preserves for part of its length a number of insertions of bristles located dorso-laterally. Traces of furca rami are lacking.

Dimensions (in mm.)	Holotype (NM Če1593)	Paratype A (ICh 100)	Paratype B (ICh 110)
Length of carapace . . . . .	c. 103	c. 35	—
Dorso-ventral width of carapace . . . . .	58	c. 25	—
Length of last abdominal segment . . . . .	—	16	20
Dorso-ventral width of last abdominal segment . . . . .	—	6	7
Length of telson . . . . .	—	c. 35–40 (20 mm. pre- served)	38

*Remarks.* New finds of the abdomen of *P. schuberti* show a distinct resemblance to *Aristozoe parabolica*. Their common features are especially the small number of abdominal segments, a considerable elongation of the last segment, and a distinctly curved telson. It is important to note that in neither of these species could traces of furcae be established.

The telson of *P. schuberti* differs by its stronger curvature and shorter head from the isolated telson described by Novák (1886b) from the same formation as *Aristozoe solitaria*. On the other hand the possibility that the specimen described by Fritsch (1907) as *Onchus siluricus* Fritsch is conspecific with *P. schuberti* cannot be excluded. Fritsch's original from the Kotýs-locality, near Koněprusy (coll. NM Če 1456), probably from the lower part of the Lochkov formation in the Radotín facies, is doubtless a fragment of an aristozoid phyllocarid. The curved spine bearing longitudinal ridges represents the telson and the fragments interpreted by Fritsch as intraclavicula and scapula are the remains of abdominal segments. The resemblance between Fritsch's original and the telson of *P. schuberti* is striking. As these occur in the older horizon of the Lochkov limestones (*Monograptus uniformis* Zone) where the occurrence of *P. schuberti* has not yet been proved by the discovery of carapaces, and as the telsons of different representatives of the family Aristozoidae resemble each other so closely that it is not yet possible to exclude assignment to another species, the author does not at present consider '*Onchus*' *siluricus* synonymous with *P. schuberti*.

*Occurrence.* *P. schuberti* is so far only known with certainty from the classical locality at Kosoř, south-west of Prague, where it occurs in the same beds as *A. parabolica*, with a rich marine fauna (Chlupáč 1953). It is found in intercalations of dark fine-grained

limestones and in highly calcareous shales, and occurs about as abundantly as *A. parabolica*; twenty-five specimens have so far been found.

Family Ceratiocarididae Salter 1863

Genus *Ceratiocaris* M'Coy 1849

*Ceratiocaris cornwallisensis* Copeland 1960

1960 *Ceratiocaris cornwallisensis* Copeland, pp. 49, 50; pl. 8, figs. 1, 2; pl. 9, fig. 5.

*Ceratiocaris cornwallisensis damesi* subsp. nov.

Plate 12, figs. 9, 10; Plate 14, figs. 3-5; Plate 15, figs. 1-4; text-figs. 3-5

1886b *Ceratiocaris damesi* Novák, p. 676 (*nomen nudum*).

*Derivation of name.* After Mr. W. Dames; the original manuscript name suggested by Novák has been used.

*Holotype.* Two last abdominal segments and telson, NM Br283 (Pl. 15, fig. 1; text-fig. 3).

*Type locality.* 'Černá rokle', Kosoř, near Praha, Czechoslovakia.

*Horizon.* Lochkov Formation, Radotín-Limestones facies, Lochkovian, Zone of *Monograptus hercynicus*, Silurian.

*Material.* Two incomplete carapaces; a great number of caudal appendages partly with abdominal segments; and about thirty mandibles.

*Description.* Carapace incompletely known, lacking anterior region (text-fig. 5). Outline suboval, the dorsal border much less convex than the ventral one, posterior border truncate, a narrow marginal rim, the border line distinctly marked. Surface sculpture not observed.

The abdominal part has not yet been found with a carapace in natural position, so that the number of abdominal segments is unknown. In several specimens disarticulated

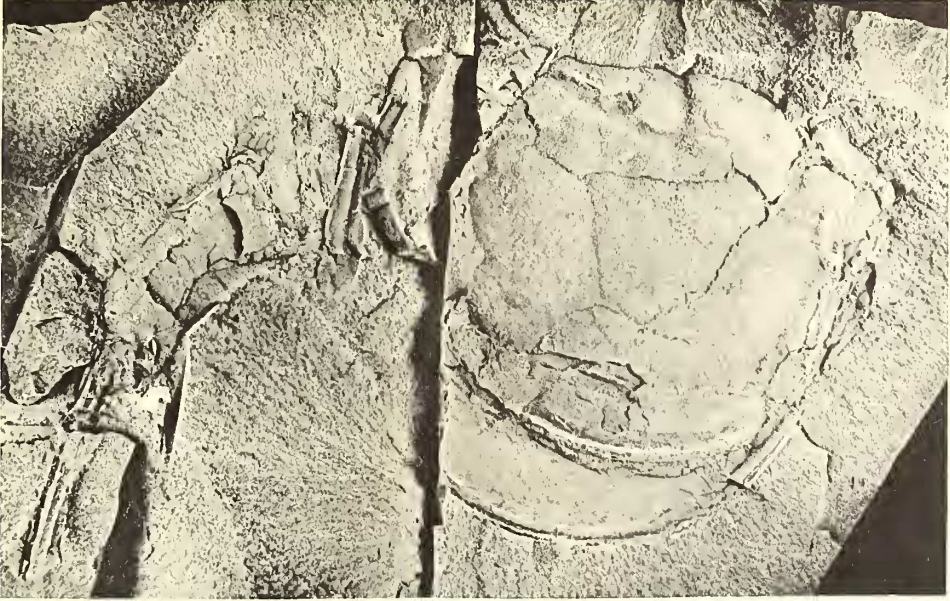
EXPLANATION OF PLATE 13

The specimens in Figs. 1-3 and 5 were coated with ammonium chloride before being photographed. Figs. 1-3. *Aristozoe parabolica* Perner. Kosoř, near Praha. 1, Paratype A, ICh 105, laterally compressed specimen showing abdominal portion and telson in natural position (left valve of the carapace displaced ventrally relative to the right valve),  $\times 1.1$ . 2, 3, Paratype B, ICh 102, left valve of the carapace only slightly compressed showing the vaulting and nodes differently illuminated,  $\times 1.1$ . Figs. 4, 5. *Pygocaris schuberti* Perner. Kosoř, near Praha. Paratype A, ICh 100. 4, Incompletely preserved carapace, abdominal segments and telson in natural position,  $\times 1$ . 5, Detail of the same specimen showing the articulation of the last abdominal segment and telson,  $\times 2$ .

EXPLANATION OF PLATE 14

The specimens in Figs. 1-3 and 5 were photographed under alcohol, and the specimen in Fig. 4 was coated with ammonium chloride before being photographed. Figs. 1, 2. *Montecaris brunnensis* Chlupáč. Bedřichovice, near Brno. 1, Paratype C, ICh 200a. 2, Counterpart of the same specimen, ICh 200b,  $\times 1$ . Figs. 3-5. *Ceratiocaris cornwallisensis damesi* subsp. nov. Kosoř, near Praha. 3, Paratype NM 1114, laterally compressed telson showing the backwardly curved posterior projection in the proximal portion,  $\times 1.8$ . 4, ICh 109, isolated non-compressed mandible of a big specimen,  $\times 1$ . 5, ICh 115a. Compressed mandibles and isolated fragments of the carapace,  $\times 0.9$





2



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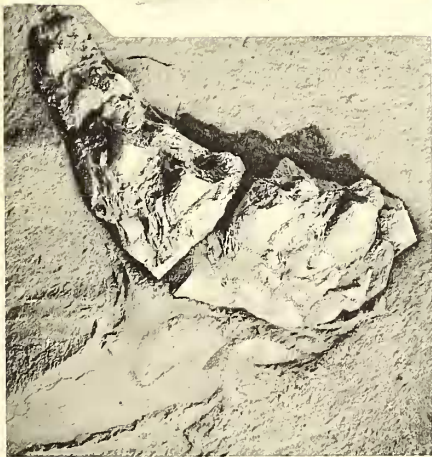
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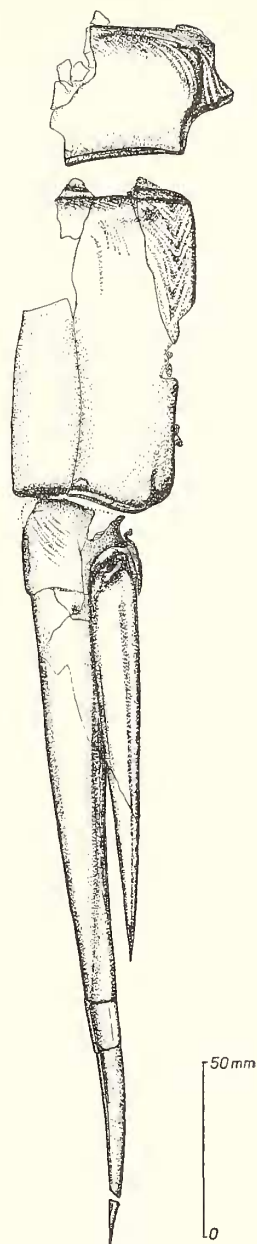


abdominal segments and caudal appendages are, however, preserved near the remains of carapaces, so that there is no doubt that they belong to the same subspecies.

It is impossible to decide which abdominal segments the isolated specimens represent, but two last abdominal segments are preserved in natural position. The penultimate segment, e.g. in the holotype (text-fig. 3; Pl. 15, fig. 1), shows a subquadrate outline and is much shorter than the last segment (the ratio of its length to the length of the last segment is 1:2.5). Several pieces show sculpture in the anterior part formed by fine anastomosing small ridges and striae of unequal thickness. In front they run subparallel to the anterior border, but they soon turn obliquely postero-ventrally.

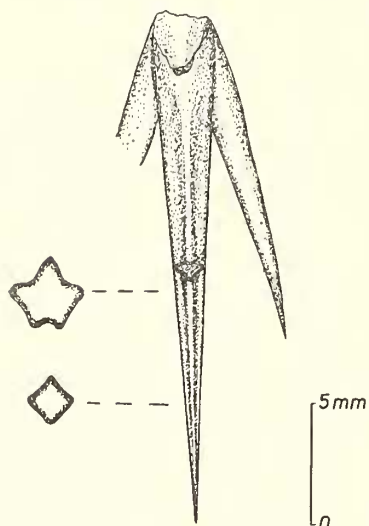
The last abdominal segment is considerably elongated and is about two and a half times longer than the penultimate segment. It is more or less flattened on all specimens so that the original contours are not preserved. It has a subquadrate outline, the length exceeding at least twice the dorso-ventral width. At the anterior border the segment, even in the flattened specimens, is arched and suggests the contours of the original segment. In this position the sculpture is very often preserved and is seen to consist of unequally thick small ridges and striae as on the penultimate segment. Anteriorly the striae are subparallel to the anterior border, but they soon turn away postero-ventrally from the dorsum. On the holotype it can be clearly observed that these small ridges and striae on the ventral side form acute angles with vertices pointing backward. The posterior part of the last segment is unornamented in all the specimens so far known. Near the posterior border the segment was obviously thickened as in the anterior region, although to a lesser extent.

The most frequently found specimens are large caudal appendages, represented by a long telson and shorter lateral spines. The telson is long and dagger-shaped, with a conspicuously broadened strongly vaulted head, and preserves its convexity at least in part, even in the compressed specimens. The telson is almost straight and gradually tapers backwards. In large specimens only was it possible to establish that the distal part of the telson is very moderately dorsally curved. The head of the telson is provided anteriorly with a narrow articulation plate. The head carries on both sides of the ventral surface two strong distinct tooth-like projections, the anterior of which is simply pointed, while the posterior one is produced into a short curved spine (Pl. 14, fig. 3). The head bears traces of sculpture formed as in the abdominal segments by irregular small ridges and striae running postero-ventrally from the anterior border.



TEXT-FIG. 3. *Ceratiocaris cornwallisensis damesi* subsp. nov. Holotype NM Br283, laterally compressed two last abdominal segments and caudal appendages.

A cross-section of the telson cannot be obtained from the large, more or less compressed specimens. When the specimens are laterally compressed only two longitudinal carinae are noticeable, one at the dorsal border, and the other at the ventral. Another lateral longitudinal line, indistinctly marked in relief, runs postero-ventrally from the



TEXT-FIG. 4. *Ceratiocaris cornwalliensis damesi* subsp. nov. ICh 139, telson with furcal rami of a young specimen showing the section of the central spine.

head. It was possible to study in detail the cross-section and nature of the telson on undeformed young specimens from the locality Šamor, near Liteň. The telson shows five longitudinal ridges. A prominent dorsal ridge running along the median line of the telson has a sharp crest, and two dorso-lateral ridges have rounded crests as do the two ventro-lateral ridges. The ventral concavity of the telson in the proximal part is conspicuous where the section of the spine is star-shaped. This ventral concavity dies out posteriorly and the section of the spine becomes subpentagonal. The ventral concavity disappears completely in the distal part of the telson, and the two ventro-lateral ridges fuse into one so that the section of the telson becomes subquadrate (text-fig. 4).

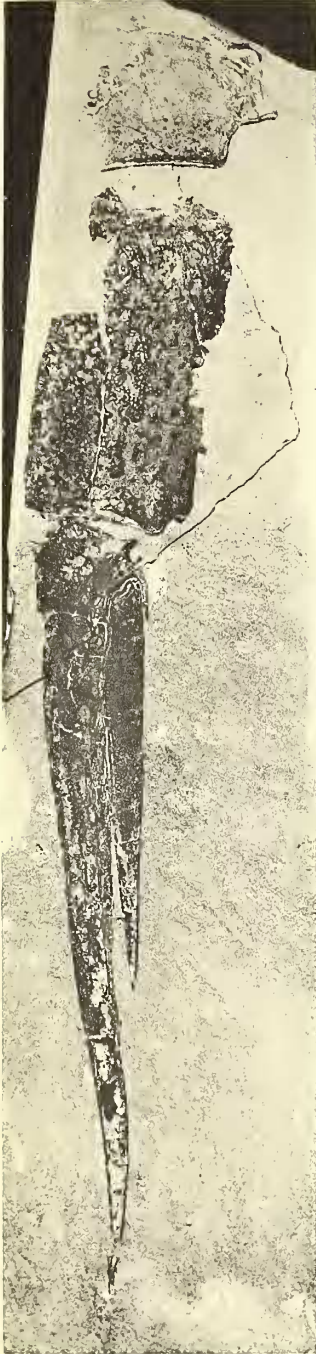
The pits marking the insertions of bristles are situated laterally on the telson between the dorso-lateral and ventro-lateral ridges. In the paratype from Kosoř (ICh 250) it is possible to establish that the pits do not form a single row but several longitudinal rows of rounded pits of different sizes (Pl. 12, fig. 10). The largest pits form a row near the dorso-lateral ridge, under which are three to four rows of tiny insertions not quite regularly arranged, the size of the latter decreasing ventrally. Some similarity exists with the specimens described by Barrande (1872) as *Ceratiocaris tardus* from the Devonian of Bohemia.

In the adult specimens the lateral spines of the furca are approximately two-thirds of the length of the telson (in the young specimens the ratio of the length of telson to lateral spines ranges around 5:3). The spines taper posteriorly more rapidly than the telson, and older specimens (text-fig. 3; Pl. 15, fig. 3) show a slight dorsal curvature. Only two longitudinal ridges are visible on the laterally compressed specimens, namely at the dorsal and ventral border. The unflattened specimens from Šamor show a subovate cross-section of the spines, sharp dorsally. The exterior surface of the lateral spines

#### EXPLANATION OF PLATE 15

The specimens in Figs. 3 and 4 were coated with ammonium chloride before being photographed. Figs. 1-4. *Ceratiocaris cornwalliensis damesi* subsp. nov. Kosoř, near Praha. 1, Holotype, NM Br283, two last abdominal segments and caudal appendages laterally compressed,  $\times 0.3$ . 2, Paratype A, ICh 143, two last abdominal segments and caudal appendages in lateral position,  $\times 0.5$ . 3, ICh 113a, incompletely preserved and laterally compressed caudal appendages showing a slight bending of the spines,  $\times 0.7$ . 4, ICh 142, isolated abdominal segment showing the sculpture,  $\times 1.8$ .





1



2



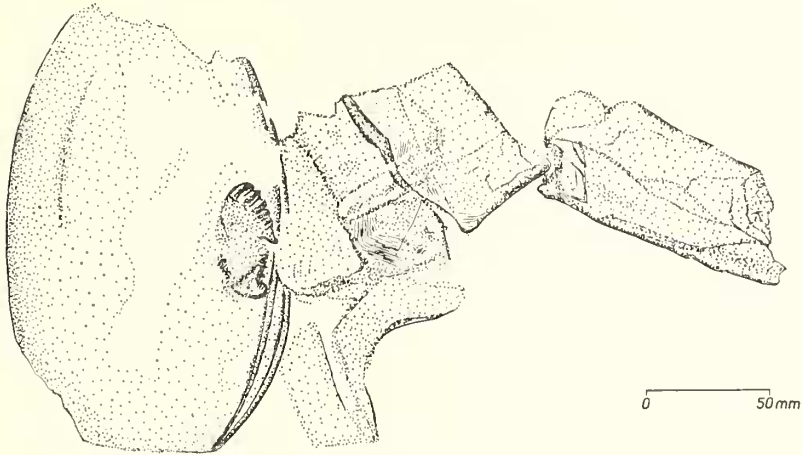
3



4



shows no traces of sculpture. Only in the casts from Šamor were irregular, fine, postero-dorsally oriented ridges observed which indicate the sculptured interior surface of the integument. Traces of circular insertions of bristles form a longitudinal row on the lateral spines just under the dorsal ridge, but they are rarely preserved.



TEXT-FIG. 5. *Ceratiocaris cornwallisensis damesi* subsp. nov. KU 1208. Displaced carapace, mandibles, and abdominal segments.

In addition to the carapace, abdominal segments, and caudal appendages, mandibles are known, but they are usually isolated from the other parts of the shield. In several cases, however, they were found either directly within the carapace (but not in natural position) or close to the carapace so that the assignment to *C. cornwallisensis damesi* subsp. nov. is certain. The mandibles may be up to 50 mm. long. The corpus mandibulae is produced into a comparatively long sickle-shaped process formed of a much thinner carapace than that over the oral part. The arcuate oral part proper is very massive and carries four to six paired, partly alternating pointed teeth, which have radially running furrows on the surface.

*Dimensions.* *Ceratiocaris cornwallisensis damesi* subsp. nov. is probably the largest Bohemian phyllocarid, and of all Bohemian species only *C. bohemica* Barrande attains similar dimensions. The specimens found indicate that the length of the whole body can be estimated as being up to 70–80 cm.

<i>Dimensions (in mm.)</i>	<i>Holotype</i> (NM Br283)	<i>Paratype A</i> (ICh 143)	<i>NM 35615</i>
Length of penultimate abdominal segment .	37	—	—
Length of last abdominal segment . . . . .	90	70	—
Length of telson . . . . .	210	c. 150	c. 300
Length of lateral spine . . . . .	117	85	210

The carapace (paratype C, KU 1208) is about 200 mm. long, the maximal dorso-ventral width being 110 mm. In ten young specimens from Kosoř and Šamor the length of the telson varies between 17 and 50 mm., the length of the lateral spines being 11–31 mm.



*Remarks.* The described specimens from the uppermost Silurian of Bohemia were formerly mentioned by a number of authors as *Ceratiocaris damesi* Novák (Novák's manuscript name) but without description and illustration. Copeland (1960) has recently described *C. cornwallisensis* from the Upper Silurian of Cornwallis Island in the Arctic area of Canada, and it is very closely related to *Ceratiocaris damesi* Novák MS. Both forms have the same general structure and agree in the main features of sculpture of caudal appendages and abdominal segments. A more detailed comparison of the specimens figured by Copeland (1960) and the material from Bohemia reveals, however, some differences of lesser importance. The difference between the length of the telson and the lateral spines is in the Bohemian specimens somewhat greater than in the specimens figured by Copeland. In the Canadian form no curvature of the lateral spines has been established. From Copeland's description there seem to be differences in the cross-section of the telson but, considering the compression of the Canadian material, they are probably only secondary. According to Copeland's description the length of the last abdominal segment is much shorter than in the Bohemian specimens; however, according to W. D. I. Rolfe (*in litt.*), the last segment in the holotype of *C. cornwallisensis* is longer (61 mm.); the indication of a shorter length was due to the mistaking of casual cracks for the boundary between segments. The comparison shows that despite close relationship it is not possible to regard the Canadian and the Bohemian forms as completely synonymous. Since a number of features in the Bohemian material could not be established in the described Canadian material, the author considers it appropriate to designate the Bohemian form as a separate subspecies which may be a geographical mutation of the Canadian species.

*Occurrence.* The occurrence of *C. cornwallisensis damesi* subsp. nov. is restricted in the Barrandian to the uppermost Silurian Lochkov Formation (Lochkov stage) in which it is abundant in some places. Most of the material comes from the Radotín and Kosoř facies of this formation from the Černá rokle quarries near Kosoř (Zone of *Monograptus hercynicus*), where it is accompanied by a rich marine fauna. This subspecies has been found in the same beds at Přídolí near Velká Chuchle, in the former Podolí Cement Works in Praha 14, and in the Švarcava valley near Solopysky, &c. (for more detailed records see Chlupáč 1953). The subspecies was also found in the organo-detritic facies of the same age in the Kotýs Limestones, at Šamor, near Liteň, where it occurs frequently in beds of light grey limestones with a rich trilobite fauna.

*Ceratiocaris(?) coherbaria* sp. nov.

Plate 12, figs. 6, 7; Plate 16, figs. 4-9

1960a *Ceratiocaris* sp. nov. Chlupáč, pp. 152, 157, &c.

*Derivation of name.* From the Latin *co-* and *herbaria* = herbaceous, indicating the common occurrence with plant remains.

*Holotype.* Telson figured on Plate 16, fig. 7; ICh 126.

*Type locality.* 'Volfova rokle', Karlštejn, near Beroun, Czechoslovakia.

*Horizon.* Srbsko Formation, lower part (Kačák Beds), Upper Middle Devonian (Lower Givetian).

*Material.* Twenty-five telsons, mostly with furca.

*Diagnosis.* A species referred only with reserve to the genus *Ceratiocaris* McCoy, characterized by a diagnostic ornament on the telson and furca. The ornament is formed on both sides of the median ridge of the telson by dense fine broken lines, the angles of which point anteriorly, and on the lateral spines by distinct oblique lines. The telson bears a pair of small lateral telson-spines.

*Description.* The only part of the shield known so far is the telson and paired lateral spines (furca). The telson is produced as a straight central spine of medium length and is slightly longer than the lateral spines. It tapers rapidly posteriorly at an angle of 7–10°, and the telson head is only slightly inflated. A distinct median dorsal keel runs the length of the telson. In well-preserved specimens a pair of lateral spines may be seen just over half-way along the telson; the spines are slightly curved and point obliquely backwards. The characteristic ornament of the telson consists of fine broken lines, which form sharply pointed arches, with vertices pointing anteriorly. When dorsally compressed these arches are arranged symmetrically in relation to the longitudinal keel. Only some specimens show a row of closely spaced circular pits marking points of insertion of lateral bristles. The lateral spines (furcal rami) are almost as long as the central spine. They taper rapidly posteriorly at an angle of about 5–8°, while the dorsally compressed specimens have their distal ends slightly bent inwards towards the central spine. A longitudinal keel runs along the interior margin of the lateral spines, and some specimens show a row of tiny circular pits marking the insertions of setae. The ornament on the lateral spines consists of striae running obliquely from the interior to the exterior margin; it is more distinct than on the telson. The striae become finer towards the exterior margin. The angle formed by the exterior sides of both spines of the furca is fairly constant and varies from 60° to 80°.

<i>Dimensions (in mm.)</i>	<i>Holotype (ICH 126)</i>	<i>Paratype A (ICH 124)</i>	<i>Paratype B (ICH 133)</i>
Length of telson along midline . . . .	37	21	20
Width of proximal part of telson . . . .	6	3.3	3.3
Length of lateral spines along exterior margin	26	15.2	17
Angle between exterior margins of lateral spines	c. 65°	60°	70°

*Remarks.* Since only caudal appendages have so far been found their generic assignment must remain questionable. The author only tentatively refers the specimens described above to *Ceratiocaris* because the characteristic ornament of the telson differs from all other representatives of the genus. Similar ornament may be seen in Bohemian Silurian representatives of the group of *Ceratiocaris stygia* Salter, e.g. *C. scharyi* Barrande, which have an ornament of pointed arches on the last abdominal segment, although this ornament does not usually continue on to the telson. A certain analogy in the ornament can be seen in the specimens described by Novák (1886a) as *Phasganocaris pugio*, which according to Gürich (1929) represents the telson and possibly the abdominal segment of *Aristozoe memoranda* Barrande. The shape and spacing of the lines are, however, quite different. On the other hand the ornament of oblique lines on the lateral spines is similar to that of a number of phyllocarids, e.g. of the genus *Mesothyra* Hall

from the family Rhinocarididae (especially of *Mesothyra neptuni* Hall) and of the genus *Montecaris* Jux (e.g. *M. antecedens* Chlupáč), &c. The fact that neither the carapace nor other parts of the body except caudal appendages have so far been found suggests that as in many other ceratiocarids only the caudal appendages were suitable for fossilization. It is interesting to note that most of the specimens of caudal appendages are preserved in dorsal or ventral position and only exceptionally in lateral position. The fairly constant angle formed by the lateral spines suggests a close connexion between furca and telson. The weight of the central spine being greater the specimens were necessarily deposited on the sea bottom on the dorsal or ventral side, while the lateral spines remained symmetrically extended on both sides of the telson.

*C.(?) coherbaria* sp. nov. is the youngest known phyllocarid from the Central Bohemian earlier Palaeozoic and comes from beds where no phyllocarids have previously been found.

*Distribution.* *Ceratiocarid(?) coherbaria* sp. nov. appears rarely in dark calcareous shales of the Kačák division of the Srbsko Beds which form the base of the Givetian in the Barrandian area. Both an abundant marine fauna (tentaculitids, lamellibranchs, brachiopods, &c.) and especially terrestrial plants occur together with this species (see Chlupáč 1960; Obrhel 1961). During recent study *C.(?) coherbaria* sp. nov. was found in several localities, e.g. in Karlštejn-Volfova rokle and at the locality 'U dubu' near the forestry, Srbsko, Koda, and the hill Koreňský vrch. For further details of localities and accompanying fauna see the author's stratigraphical paper (1960a).

#### GENUS CONCAVICARIS Rolfe 1961

*Remarks.* The commonly used name *Colpocaris* Meek 1872 has been replaced by *Concavicaris* Rolfe, since the former was a junior homonym of *Colpocaris* von Meyer 1862 (see Rolfe 1961).

*Orientation of the carapace.* The orientation of the valves of the carapace is disputed in this genus. While Meek (1875) considered the part with a prominent sinus-like incision to be posterior, most of the later authors, e.g. Clarke (1900), Gürich (1929), Cooper (1932), Shimer and Shrock (1944), regarded the sinus as being anterior. By analogy in many other phyllocarids the posterior thorny projections and incisions are more prominent than the anterior ones, and the conspicuous broadening of the carapace towards the sinus in *Concavicaris* suggests that Meek's original orientation is correct. This is

#### EXPLANATION OF PLATE 16

The specimens in Figs. 2-5 and 9 were photographed under alcohol, and those in Figs. 6-8 were coated with ammonium chloride before being photographed.

Figs. 1, 2. *Concavicaris incola* sp. nov. Hády, near Brno. ICh 176a. 1, Carapace (left valve),  $\times 1.7$ .

2, The same specimen photographed under alcohol,  $\times 1.7$ .

Fig. 3. *Concavicaris desiderata* (Barrande). Pekárek mill, near Choteč. Paratype A, ICh 194, carapace,  $\times 2.5$ .

Figs. 4-9. *Ceratiocarid(?) coherbaria* sp. nov. Karlštejn, near Beroun. 4, Paratype B, ICh 123b, caudal appendages,  $\times 2.4$ . 5, Paratype A, ICh 124, caudal appendages,  $\times 2.4$ . 6, Paratype C, ICh 122, the right lateral spine showing the sculpture,  $\times 1.9$ . 7, Holotype, ICh 126a, caudal appendages,  $\times 2.1$ . 8, ICh 126b, counterpart of the same specimen,  $\times 2.1$ . 9, The same specimen, detail of the telson showing the small lateral telson-spines,  $\times 5.8$ .